WORLD INTELLECTUAL PROPERTY ORGANIZATION International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁵: B25J 21/00, H02K 16/00

A1

(11) International Publication Number:

WO 94/23911

(43) International Publication Date:

27 October 1994 (27.10.94)

(21) International Application Number:

PCT/US94/04040

(22) International Filing Date:

13 April 1994 (13.04.94)

(30) Priority Data:

08/048,833

16 April 1993 (16.04.93)

US

(71) Applicant: BROOKS AUTOMATION, INC. [US/US]; 41 Wellman Street, Lowell, MA 01851 (US).

(72) Inventor: HOFMEISTER, Christopher, 176 Wheetwright Road, Hampstead, NH 03841 (US).

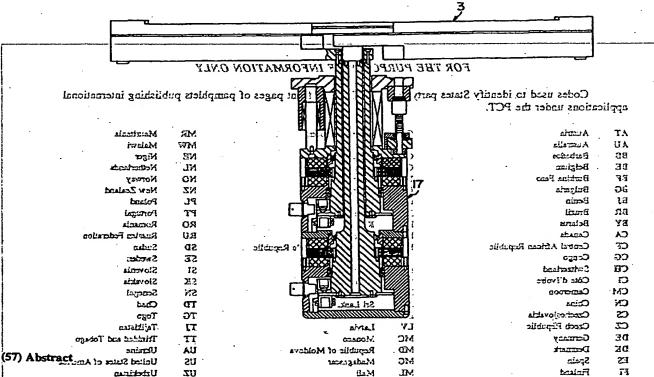
(74) Agent: NIELDS, Henry, C.; Nields & Lemack, Suite 8, 176 E. Main Street, Westboro, MA 01581 (US). (81) Designated States: CN, JP, KR, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published

With international search report.

BEST AVAILABLE COPY

(54) Title: ARTICULATED ARM TRANSFER DEVICE



A concentric-shaft rotational drive system for an articulated arm transfer device (3) adaptable for imparting movement to an assembly inside a vaccuum chamber (2) wherein rotary movement is imparted to rotors (7, 9) inside the vaccum chamber (2) by means of magnetic

fields produced by stators (8, 10) outside the vaccum chamber.

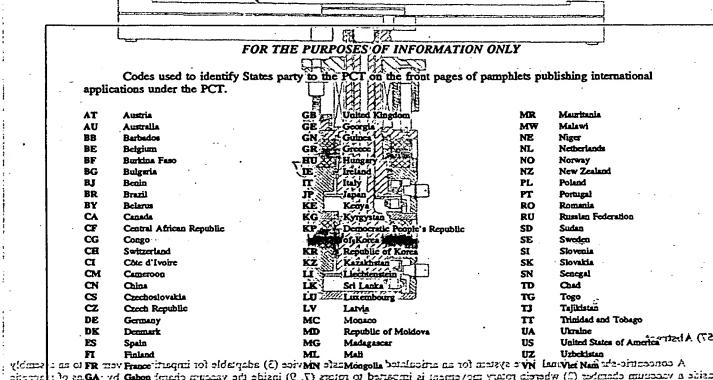
WORLD INTELLECTUAL PROPERTY ORGANIZATION International Bureau



אם משירי משמשת משששי ומתום וואודארון ופשא

1) International Publication Number: WO 94/23911		(51) International Potent Classification 5:		
3) Leternational Publication Date: 27 October 1994 (27.10 94)	A1 (4	B25J 21/00, 11(2K 16/00		
(61) Designated States: CN, Fr. KR, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, II, LU, MC, NL, PT, SD,		21) Interoccional Application Namber: PCT/US94/04040 22) Interoccional Application 13 April 1994 (13.04.94)		
Fablished With international search report.	(#2.#0.8 - EU	(20) intermidenci Filing Date: 13 April 1994 (1 (30) Priority Date: 68040,833 16 April 1993 (16.04.93)		
en e	USI: 41	(72) Applicans - SKODKS ALTOHUKUKON, INĆ. (KS.) Velikac Svec), Izvoli MA (1881 (KS).		
	:dig/तमाध	72) Inventor: HOFMIESTER, CESTuphen 176 Viber Road, Hempoudd, NR 63641 (US).		
	, 176 E.	(76) Agona MZLDS, Henry, C.; Walds & Lemault, Suiw S Mais Street, Weslicto, MA 01581 (US).		
•				

(54) Title: ARTICULATED ARM TRANSFER DEVICE



eside a vaccuum chambur (2) wherein rotary movement is imparted to rotors (7, 9) inside the vaccum chamb coded by :AD as of : agreeic elds produced by emions (8, 10) outside the vacuum chamber. WQ_94/23911\TOS PCT/US94/04040

a vafer ejector acceptor arm having directional air jets. The wafer ejector acceptor and marked defaulth of the wafers into or out of the carrier from or onto the air slide, which moves the wafers to or out of the wafers and wafers and wafers of the wafers to or item a work state on.

U.S. Patent Nos. 4,062,463, 3,874,525 and 4,028,159 also disclose wafer transfer devices noification and a formatic

10 Process imaging plates, such as The material transfer devices. The material transferred might violate, but not be limited to, semiconductor wafers, such as refisition and gallium Arsenide, semiconductor wafers, such as substrates, such as High Density Interconnects, semiconductor substrates, such as High Density Interconnects, semiconductor or substrates, such as High Density Interconnects, semiconductor or substrates, and large area display panels, such as Active Matrix LCD substrates. "Active Matrix and of substrates."

2. Description of the Prior Art

20 Telemant The transfer of delicate silicon wafers of the like detection as plurality of work stations or locations in the manufacture of semiconductor devices presents unique handling problems. The silicon wafers are very delicate and have highly polished surfaces. When the wafers are abruptly moved,

25 They tend to slide. This sliding action can cause the silicon wafers to abrade or alternatively can cause damage to their

which is rotated by a belt. It appears that designed are repeared are numerous desirable and the prior art for the prior are numerous devices described in the prior art for a rotary seal. The policy middle wifers a rotary seal. To be bolicy widely will a rotary seal.

30 eviro a control of 1823, 836 discloses an apparatus which sincle of 1828 a control of 1829 a contro

U.S. Patent No. 3,370,595 discloses a wafer transfer handling apparatus having an indexable carrier for transferring wafers to and from work stations. Wafers enter and leave the wafer carrier on an air slide with the aid of

40

WO 94/23911 TOI PCT/US94/04040

a wafer ejector acceptor arm having directional air jets. The wafer ejector acceptor arm controls the driving of the wafers into or out of the carrier from or onto the air slide, which moves the wafers to or from a work station.

U.S. Patent Nos. 4,062,463, 3,874,525 and 4,028,159 also 5 disclose wafer transfer devices which include either pneumatic VII components or gripping devices for handling the wafers. Judim bau.S.a Patenta Nos. 4,666,366 and 4,909,701 disclose wafer 23 transfer handling apparatus having an articulated arm assembly 10 gaiwhich extends and retracts in a "froglike" motion to transfer no jan object such as a wafer between a plurality of locations. Two articulated arms are operatively coupled such that when kinone arm is driven by a motor the articulated arms extend, and retract in a "froglike" or "frogkick" type of motion. platform is coupled to the arms and has the object to be 15 transferred disposed thereon. exil ed. 10 Patent No. 4,951,601 discloses wafer transfer or handling apparatus having an articulated arm assembly which enimoludes a concentric-shaft, rotational drive system. However, such drive system requires rotary seals which can eval bus elected view system requires rotary seals which can In the drive system of U.S. contaminate the vacuum chamber. ropiliz end esuso morros gnioris sint entre character years according to the property of the control of the con riell of edition of the rest of the cause of It appears that the drive 115 which is rotated by a belt. 25 rotates in an aperture in the vacuum chamber, thus requiring The hollow middle shaft 96 is mounted on a a rotary seal. drive 05 a drive 05 a cable 103 mounted on a drive 30 a drive with world with world with the color of the col don which is rotated by a belt. It is not clear which blood a supply carrier with a plurality or leages to hold components are inside the vacuum, but it seems clear that some must rotate in an aperture in the vacuum chuck is accared to an elevator which chamber, thus requiring a rotary seal. The device of the present invention has no such rotary seals. All bearings of as no till some such rotary seals. All bearings of as the present invention are entirely within the vacuum, and all ...muupsv. ant nidtiw ylaritna ara grang pritator Falent No. 3,3/0,399 alschoses a water transfer

handling apparatus having an indexable carrier for transferring wafers to and from work stations. Wafers enter and leave the wafer carrier on an air slide with the aid of

35

40

WO 94/23911 PCT/US94/04040

Figure 8 MOITMEVMI:: HT : 40:YARMMUZilar to that of Figure s doing a The impresent dinvention approvides and geomeentric-shaft rotational drive system for an articulated arm transfer device adapted to transfer objects, such as silicon wafers, camera lenses, crystal oscillators for the like Abetween a plurality epns of locations; disposed in various axial and radial planes. To S fiswThetidrive; system permits the entire sarticulated arm refrassembly tobbefrotated in a radial plane edlike the apparatus s agof theapriorgart, such rotation is done when the genda effector dentral aperture through .noition deportain anutrage faiting flads reaTheadrive system salso spermits the splatform assembly to attabe displaced in an axial direction. The assembly is adaptable end for use in a variety of environments, including operation in ers ativacuum; chamber sor other controlled cenvironment and The 15:manassembly may be mounted for movement inside advacuum chamber bodiwithea vacuum seallbetween the assembly and its supporta to one in which they rotate togather, and another in which zevrez noidom rembrief. Description (Ofether Drawings abor year) restal edFigure, listacentral rection throughta dual shaft device 20 mis constructed in accordance with the invention and connected so as to drive an articulated arm transfer device of the type end disclosed ain = U.S. sepatent Norss, 180, 276 ato Hendrickson and radiassignedato the assignee of the instantapplication; rake Jisda 190Figure 20istardetail roffa portion of the central section and attains a maximum outer diameter correspondinguing of 25 ensitua Figure B' is a detail of a portion of the central section the outer shaft 4, and a corresponding suppit to is zi e to:Figure 4:fis:fa:plan view:of>the:device:of>Figure 1::a a bus , a Figure 5 eis ian isometric sketchtof adprior barto device; .e rosFigure 65 istan plantaiew of the rdevice of prigurer to but 10 gnimodified to drive santarticulated arm transfer device of the end typesdisclosed in compending sapplication Serial No. 1997, 773 filed December 128 v 1992 by Eastman and Davis and assigned to Each rotor-gnoitagilggs/thesenglessigning-rotor notal 35 zeire2 %Figure eff iss addentralomsection e along the oline v7-7 of 3. manufactured by MFM Technology, Inc., 200 Tibnse; Otarupi Jue, Ronkonkoma, New York 11779.

WO 94/23911 TO9 PCT/US94/04040

Figure 8 Wis accentral section similar to that of Figure ##snid-randushowing anothervembodimentwoffitheminvention in which a rotational drivebyolqmer enceshard two brakes are temployed with landitation adapted to transfer objects, such as silicon wafers, camera lenses, MOITMEVAINS ENTRY OF LITTLE LED DESCRIPTION OF LITTLE RIVERTION, session 1 . zensiq laiReferring to Figuresvicthrough 47 a mounting flange mis leis attached to an apertured region of the bottom wall 2 of audsasyacuum chamberswithin iwhich ran barticulated; armimtransfer rosodevicere3 sis rsupported at a The amounting flange titself has a central aperture through which atwo aconcentric output shafts 10 of vextend: "The couter shaft is designated 4; and the inner shaft eldeissidesignated as a seat the rextremities of athemoutput shafts at awithing the avacuum chambers appilot bearing 6 separates the adT shafts, and supports them upon each other ad The two shafts are 15 gamindependently rotatable me However, fin the preferred embodiment of the invention the relative motion of the shafts is dimited to one in which they rotate together, and another in which they rotate in topposite directions and The Thorner motion serves ecivto rotateithe articulated armatransfer device, sand the latter 2038 Emotion preserves obto sextend; and wretract to the marticulated arm? as to drive an articulated arm transfer. spiveb refaratione bas moskTheminnershaft (is longer than the outerishaft frank the extremitystof othetrinner shafts outside sthet vacuum sichamber noi-extends-beyond the corresponding extremity of the couter shaft and attains a maximum outer diameter corresponding to That of a not the outer shaft. TA rotor of is supported on the outer surface of the outer shaft 4, and a corresponding stator 18 supported outside ethed rotor of misimilarly, savgrotor 9 is : 95 supported rong the outer; surface; of the sinner shaft 15, and a 30 Jud corresponding stator 10 is supported outside the rotor 9. end Each statories part of a drive which rotates the corresponding ETT shaft on Asicappears; thereinafter, meeach rotors cissinside the filed Decemb muujay isht abistuorisin rotats, dasambuujay to Each rotor-stator pair 57, 8 sand 9, 10 may form partiof a 35 to conventional brushless iDC to to the same the same of the sa manufactured by MFM Technology, Inc., 200 Thirteenth Avenue, Ronkonkoma, New York 11779.

WO 94/23911 TOG PCT/US94/04040

Territ editRotaryxmotioniis imparted to teach shafteby well-known as servomechanismittechniques, a wherein sa suitable a signal by a stator clamp 37, arotate; editional edition of the cobabiyong The warying a position yof feach eshaft as ditionates is 5, codetected by na suitable sensing mechanism in combination which a suitable coded diskotorotherlike of For example, and coded mo pattern of opaque portions on a transparent disk may be caused 71 -to pass between a light source and a light detector In lieu ent of such van optical neensing mechanism; a magnetic sensing 10302 mechanismo may ebe employed: wherein esa rcoded epattern magnetized portions on a magnetic disk may be magnetically the sensing mechanismicmay be Alternatively, is mechanical as uch as a scombination of a gear and as witch, or it may be acoustical diwith grotation of reach shaft eproducing 150: coded clicks of some sort; Leven electrostatic systems may be c. designed a For:purposes of illlustration, vand without limiting with the ascoper of the minvention othereto, sand opticalisensing movable drive housings arcbedrasabcadwww.lliw.mainsabcadwamage and to Ardiskell ispaffixed; to the outervextremity to the outer 20 aug shaft 4 sbyba a clampiplate s12 to This adisk shashab coded tpattern bas of opaque portions which pass between a dight-emitting-diode sinhousing: 13 cland; alsread; thead; 14, bfrom; which avesignal is _as_transmitted:sto athercappropriate sexternalsccircuitsthrough a and signal of eedthrough 115:01 The glight emitting diode thousing 13, 25 gd the read; head; 14; and the signal; feedthrough; 15 sare supported gaonga drive chousing 116 awhich is of ixed cande forms spart of a noivacuum-tight tubular casing 17. a The rotor 7 siscaffixed to the priouter yshaftv4, randrethemstator; [8] is saffixed betoethe drive aps housing 16 by arstator clamp 18; positioned southat the stator 30 gvi 85 cans-co-actawith the motor: Astandatwoobearings=197s 20t are entroyided between the outer, shaft 4) and the corresponding drive Dirhousing 16 upon which that udrive [is mounted: b:Similarly, a anidisk-31 is affixed to the jouter extremity of the inner shaft 10 50 by 32 clamp plate 32 59 fThis disk has are oded apateern of 35 go jopaque, portions which pass between audight emitting diode za housing 133 mandana mead bhead 134 mi from which vai signal is and transmitted to a the mappropriate sexternal circuit through a

WO 94/23911 TO9

mwomsignal feedthrough 35.03 The rotor 9 isoaffixed to the inner shaft: 5,9 and the stator 10 is affixed to the drive housing 36 by a stator clamp 37, positioned southat the stator 10 can coat Fact with the rotors 9 frand two bearings 238 7 39 are provided 50 in between the inner shaft 5 and the corresponding drive housing bebo36 Supon Which that drive is mounted to beboo elds the s beausp ed The drive housings 167 36 are of special configuration. ueiland provide an important partuof the vacuum tight casing 17 Palswhich separates the evacuated regions of the device from the atmospheric-air regions of the device. The two drive housings Villare similar in shape and are connected to each other by an Alternatively, the sensing mechoping adapter 10 (DJE Vertical motion may be imparted to the shafts by vertical gaicmovement sof the drive housings which in turn are supported on 15ad Atworlinear slides0410 and two aleadoscrews 42.askAlternates toll painthe lead screws with rotary motors may be linear motors a (servo paixor a stepper) or a voice-coildior a solenoid. To The evertically movable drive housings are separated from the mounting flange Telby suitable mbellows 143, stand the Louter extremity of the 20ame:outermost drive housing is closed off; by an end cap 44 sa Thus 68 abo the centire region within the bellows within the bellow within the er capa mays bedievacuated, fandbefrictionals motions inside of his s devacuated region is limited to that fof the cvarious bearings. LE gaiz Each drive housing has a portion which passes between its 25 bed respective crotor and stators and sufficient clearance must be 32 s iprovided between the rotor and this part of the drive housing. edd og selfioriartrækvicelle silventing figuregs. Stary motion sviis imparted to the articulated armstransfer device by rotating rod the crotate splugies Extension and Stetractions of the frog legs 30 sasis achieved by acounter rotation of the extend/retract drive 08 evishafts nogThe structures of the spresent invention reduces the s , númber and type of seals vrequired by the use of concentric disshafts constructed in a particular way. bane prior art device lo shows that frontrol may be effected by (1) simple rotation of 35 aboa shaft and (2) counter-rotation of two shafts III the device 38 21 of the invention, "(1) is provided when the concentric shafts s frotate together and (2) is provided when the concentric shafts

WO_94/23911 79 PCT/US94/04040

asd Acounter-rotate of In this adevice rotary motion rise not limited 20 22byTthe basic mechanism; but may continue in meither adirection an articulated arm transfer deviceelgns beriebb winswroth the 21 277,799The three motions: (vertical, brotary and extend/retract) 153 dimay lbe disimultaneously sactivated to provide fanys desired disdetrajectory of the end effector. 190n the other thand tin some adiacapplications salbanthree motions enmay, amot mecessarily be zi > activated; and the scope of the invention includes devices in Islaswhich only one or two lof the aforementioned three motions are 10 activated. .noitem 0.nwords equireferring now to Figure 4 in conjunction with Figures 1-3 Althe louter shaft 47 is connected to one supper arm 151 and the inner shaft: 5 is connected itorthe other supper arm 52 of an 9 ararticulated farm transfer Edevice such as athat is hown in the 15 3 2 aforementioned U.S. patent No: 57180,276 % For θ motion π(i.e.?) Empirotation of the send reffectors 53) both rotors 7; 9 turn in modification in infone direction (19) For LR Emotion (1.ex) extension reducand dretractions of sithe eendpleffectors and aleach period with 9 mirrors the other with equaliput sopposites rotation. ad: These 2011 motions are computer controlled, teusing tinputs; from the two. shoulder assembly is mounted on the outer (rots. areboone, no end to no.When Frotors 17; 2:9; turn in synchronism in cone direction, -bns-shafts-49053alsowturn in that-direction.s Referring-to-Figure 10 144; Fifthe shafts 14, starneclockwise; the upper arms 51, 52 25 xup also turn clockwise oalong bwith the rest of the apparatus \$ Conversely, if the shafts 4, 52 turn shown in Figure 4. neduccounterclockwise, the lentire apparatus shown in Figure 4 turns , ero counterclockwise ascif a on other other thand, ethe couter shaft 4 edj turnsijsclockwise:elwhile eithe prinnerjischaft;juc5 editurns 30 laucounterclockwise Lithe upper arm 51 will turn clockwise and the 8 upperoarm: 52 n.willolturn: counterclockwise. ed.Theiresulting bns movementicof bothmendieffectors[53misedownwarddin1Figure 4. adi (Conversely, reif the fouter shaft 4 turns; counterclockwise (while nao theminnershafte5sturns clockwises thefuppercarm i51 wills turn 35:ofa counterclockwise and other upper larm 52: will sturn telockwise 38 ed vThe (resulting:movement of both; end) effectors i53: iis supward in used. Figure 4.

WO 94/23911 79 PCT/US94/04040

noitoaffixed thereto samblock 54 in which the supper slave arm 55 of an articulated arm transfer device such as that shown in the (toaraforementioned co-pending) application Serial No. 1797,773 is 5 is rotateably supported. De The supper slave arm 156 sof such an emos articulated arm transfer device is saffixed to the sinner shaft ed vs is 3 as 3 to rotate sthere with slave and the state of a contract of a contract the state of a contract of a co

end fin Ithersaforementioned SUSTAD Patents in Nos meta, 666, 366 and ms it4, 909,701 ms (such saso shown din Figure 5): is imade muith two end concentric shafts, dran outer shafts not arotate athegrams in 0 153. i) motion and ran inner, shaft to generate extend/retract motion; in mit is possible to drotate the appropriate shaft combinations moistwith one motori (and sencoder) abytusing two brakes; none of which examinations the inner shaft to the souter shaft pand the other esentithe outer shaft ito the couter shaft pand the other esentithe outer shaft ito the casing pand the media accurate.

20wd edd mdfi the couter ishaft eisolocked atog the casing at and the shoulder assembly is mounted on the outer (rotate) ishaft, no , notirotation (of the shoulder, will be; possible to Rotation of the emplinner pshaft by a motoreattached to cit will seenerate extendca , retract motione as is a now odone by the extend/retract motor of 25 U Ja anyarticulated arm transfer device of the type shown in Figure 9 Conversely, if the shafts 4, 52 turn shown in Figure 4. returns 4 turns for a possible of the state A dishaft in extend/retract contion cis possible footfy therefore, answithe TouterEsshaft/casing brake istreleased Morotation of the 3 ylsuosnatumise niistluserugliw arotomwishttyda dlahavirennii th 06 equipmenting Tthe outer/shaftstand therefore win St. motion agguing .4 erupil I fiboth brakes are locked sat the rendtof each motion; and elidathen the appropriate brake is released, some encoder, when its rurus signal discombined sin a scomputer with the thrakes command; can

35 saiwindicatenthe motion of meither parameter. Elfugreater precision of the precision of

WO 94/23911 PCT/US94/04040

at IstrauBy properadesign and ause sofemagnetic and non-magnetic Ems materials, mit is possible to mount all moving parts, wincluding ai obrake shoes and motor protors, sinside of a sealed cylindrical -musicasepiwhile placing the imagnet scoils bof cally components in 5 bas atmosphere outside the casing refhis will eliminate the known dose outgassing problems and electrical efeedthroughs which degrade madu performance of systems having active electromagnets in wacuum. 27 % While this mechanism will work with any of the extending end arm assemblies typical of robots manufactured by the assignee 10 traof the instant application, a particular advantage is achieved when using the aforementioned arm shown in Figures 6 and a and 187 used in articulated arm transfer devices of the type disclosed examins the saforementioned acco-pending a application Serial 7 No. (ET 997,773, in that only one driving shaft is required at the 15:13 shoulder, eliminating the eneed of figearing on top of the the stator 10 of Fig. 1, serves to rotate tathana gnitator C.. The same salkeferring on to Figure 187 as mounting flange 61 is Trattached to an apertured region of the bottom wall of a vacuum chamber within which an articulated arm transfer device 62 is 20 zi supported. The articulated arm transfer device 625 is shown 02 Fas being of the type shown in Figures 4 and 5. of The hounting flange itself has a centralisaperture through which two seiconcentric soutput dahaftalextendaseldhed outertakhaft is , sudesignated 63 [Tand-the inner shaft is designated 645 LAE the extremities of the output shafts within the Wacuum Chamber a 25 -iipilot bearing 65 separates the shafts and supports them upon zi each cother is The itwo dishafts lare independently of otatable. However, in the device of Figure 8 only one shaft is Fotatiably Tandrivén by Jammotor, Tand afotation Liofa the 8 other shaft 30 snodetermined by two brakes poone of which to auses the sharffs to , serotate together;) and another of which causes the country , bato remain brixed tourne brokmer inotion is erves tour brate the Lararticulated armitransfer device; and the latter motion serves ersto extend and retract the articulated farm transfer device. 35 , 23 23 % The inner shaft & s longer than the outer shaft cand the basextremity rofuthed inner shaft, foutsides the cvacuum banker

extends beyond the corresponding extremity of the outer shaft.

WO 94/23911 C

oiss Asbrake 66s comprising a sdisk a 67 agof smagnetic material is prin supported on the outer surface of other outer, shafts 637 and [55] cooperates with a diska 68 a of magnetic material swhich is mi eslidably supported inside a casing 169 to finon magnetic pracuum-5 montight sumaterial All and A himagnetic special 9170; tuwhen signer gized ? ebarmagnetizes the disks 67 ac 68 so that they opress against each .mmyother and macto as a brake, spreventing rotation mofathe outer ominshaft :63. No Similarly Amay brake #71 recomprising = aidisk 72 of percomagnetic material is supported for Itherouter Surface mof the 1000 outer shaft 63, and cooperates with famdisk 873 mofemagnetic a material which is slidably supported on the inner shaft 64. Daz A magnetic coil 74, when energized, magnetizes the disks 72, .5% 73 so that they press against ceach other and fact cas acbrake end or coupling locking the shafts to teach tother & Atmotor 75, 15 and constructed similarly to the econstruction of rotor 9 and 1. stator 10 of Fig. 1, serves to rotate the inner shaft: 64. More specifically, a rotor 176 is supported nonethe outer mun surface of the inner shaft 64 psandsaucorresponding stator 77 is supported outside the rotor 76 as no The stator 77 sis part 20 awo of a drive which rotates the inner shaft 64.7 The rotor 76 is 32 inside the vacuum and the stator 77 is outside the vacuum. The rotor-stator cpairs 76,5 77 may form parts of a conventional, brushless bDC; motor; such as the Mr&nKo:Series end manufactured by MFM Technology, Linc 11 200 Thirteenth Avenue, extremities of the output shafter.itisave. avaities of the output shafter. noon mad Rotary motion is imparted to the cinner, shaft 64 by wellknown servomechanism techniques, wherein arsuitable signal is Wowever, in the device the stator 77 to be in in the device of the stator 77 to be in the dever 21 Jisa A disk 78 is affixed to the outer extremity of the inner od shafte64md This disk has to coded apattern wof vopaque mportions of which pass through a suitable encoder 793 (which may comprise, entifor example, a light-emitting diode housing and a read head, severy which a signal is transmitted to the appropriate external Circuit through a signal feedthrough) to The shafts 63 7 64 dare en supported upon suitable bearings 65 7 180 between the shafts 63, 28 1864 and suitable bearings 81, 82 between the outer shaft 63 and extends beyond the corresponding extremity of edeprises edter.

WO_94/23911 Of PCT/US94/04040

The casing 69 is of special configuration, and provides an important part of the wall which separates the evacuated regions of the device from the atmospheric air regions of the bequadevice as purposed as privated as privated as privated as privated as a privated as pri

is gributonVertical motion; may be imparted to the shafts: by overtical movement, of the casing 69 cin a manner thereinbefore described

an outer shaft mounted Larupitidiwenoitaennos midrive

The casing 69 has a portion which passes between the pintrotor 763 and stators 773 and sufficient clearance must be 10min provided between the rotor 762 and the casing £69 inversed.

Having thus described the principles of the sinvention, together, with all lustrative membodiments thereof it is to be understood that although specific terms are employed, they are eximined in a generic and descriptive sense and not for purposes of limitation, the scope of the invention being set forth infective following sclaims. Due to be the principle of the second state of the second state of the scope of the invention being set forth infective following sclaims. Due to be the second state of the second state of

I claim: \pniezon

a pilot bearing supporting said outer shaft upon said inner shaft; and

- 20 means for causing each of said stators to impress a suitable electromagnetic field upon its respective rotor so as to impart rotary motion thereto.
- 2. An apparatus for transferring objects, comprising:25 a support;
- a first upper arm supported on said support so as to be rotatable about a first axis;
- a second upper arm supported on said support so as to be rotatable about a second axis;
- 30 means for causing said second upper arm to be driven by rotation of said first upper arm;
- a first pair of forearms articulated to said first and second upper arms;
- a second pair of forearms articulated to said first and second upper arms;
- each of said upper arms being of lesser length than each forearm:

WO.94/23911 79 PCT/US94/04040

The casing 69 is **awrain**cial configuration, and provides an important part of the wall which separates the evacuated regions of the device from prize in the case of the device from its remains of the device from its regions of the device from its

a vacuum enclosure having an aperture and arecapped 5soistubulars member dounted rover said maperture and sincluding a bedisfirst edrive shousing and a second drive shousing; same worm

an outer shaft mounted for and dinside said of irstidrive eds shousing by bearings; noticed a said of said eds and concentric ed same earsinner shaft within asaid outer shaft and concentric therewith and mounted on and inside said second drive housing

Having thus described the principles (agning ton), together; the principles of the principles of the principles of the purposes of timitation, the scope of the invention being agnitude the scope of the invention being analysis.

a second stator mounted on and outside said second drive housing;

a pilot bearing supporting said outer shaft upon said inner shaft; and

means for causing each of said stators to impress a suitable electromagnetic field upon its respective rotor so as to impart rotary motion thereto.

20

25

30

35

- 2. An apparatus for transferring objects, comprising: a support;
- a first upper arm supported on said support so as to be rotatable about a first axis;
- a second upper arm supported on said support so as to be rotatable about a second axis;
- means for causing said second upper arm to be driven by rotation of said first upper arm;
- a first pair of forearms articulated to said first and second upper arms;
- a second pair of forearms articulated to said first and second upper arms;

each of said upper arms being of lesser length than each forearm:

WO_94/23911_TO4 PCT/US94/04040⁷

: galairquafirstsholding: means :pivotally coupled to said first pair of forearms and second holding means pivotally coupled to said ed osecond pair of forearms, an engagement between said first pair of forearms and adapted to sprevent irotations of dsaid of irst 5:d cholding means and antengagement between said second pair of: forearms and adapted to prevent:orotationodofesaidsusecond a pair of forearms, comprising shai; ansampnibloded a od bedalidriving;means:capable:ofodriving:said,firstcupper:arm for rotation:through:an;angle:in theirange cof bfrom:greater athan 10:1s:120:sup:to:and,including:180:sto:moversaid first holding means 12 videbetweentladefirstplextended position landcagufirstisretracted supported on said link, and means for causislinwinoitizog one and simultaneously smoving resaid second holding means between a second retracted position and a second extended position; said 15 driving means sincluding the following components 52 15 biss no assvacuum lenclosure chaving an gaperture and a capped tubular member mounted over said aperture and including a firstadrive housing and absecond drive housing; bisa reagn bisanwoutersshaftdmounted son dandsinside said first drive shaft; 20 housing by bearings; ¿zmiserclancinner fshaft Jwithin said souter shaft sand concentric therewith and mounted on and inside said second drive housing driving means capable of driving at leaspnirsed fydaid mort to sanfirstirotor mounted ton said wouter shaft amms requu greater ;tardainnerimeintedon saidlinnerishaft; researe persand first stator mounted for and foutside said first drive said including the; prizioning driving means a second stator mounted on and outside said second drive a vacuum enclosure having an aperture arfgnizuon/ped 30s paibulampilot bearing supporting said wouter shaft inponsaid 08 first drive housing and a second drive honsingfanda renni evirb dameansiforefcausing reach cofusaid stators buto mimpress a suitable electromagnetic field upon its respective rotor so an inner shaft wioteredthinoitomeratortragmiconesaric therewith and mounted on and inside said second drive housing 26 by bearings;

a first rotor mounted on said outer shaft;

WO 94/23911 TO9 PCT/US94/04040

efforearms and second holding means pivet; tropquapsed to said of forearms and second holding means pivet; tropquapsed to said educates and adapted to; aixertarifes and adapted to; aixertarifes and adapted to; aixertarifes and educates and adapted to; aixertarifes and educates and educates

a pair of forearms, comprising antirsts forearm cand a roll second of orearm, bearing pair boto forearms abeing particulated to asside first cand be second supper same by means possiblink one and the condition of the condition

bederotatably is supported on is aid; link; exactlower is hafter otatably supported on a sid link, and means for causing rotation to go one a manaftin one sense to cause rotation of the other shaftein the bis opposite sense at a supposite sense and a second a state of the other shaftein the

said: first nupper tarm theing: fixed to asaid nupper takaft; at bedges asaid second nupper arm; being: rotatably: mounted on said a glower; shaft; equitage biss revo bedauom redmem astudut said; first forearm being: fixed to asaid; lower shaft; evirb desaid: second forearm; being: rotatably: mounted on said upper shaft:

nousing by bearings;
; amray bearings;
; amray bearings;
; amray bearing bisarothed on and inside said second drive inside said second drive inside said second drive inside bisary to senongased as privirb to aldages aream privirb

morn to senar entricelenaracheuorthemostrator and upper arms.

- baddans properties of the service of the solution of the service o

an inner shaft within said jouter shaft and concentric therewith and mounted on and inside said second drive housing at by bearings;

a first rotor mounted on said outer shaft;

WO_94/23911_TO9 PCT/US94/04040

biss mistarsecondrictor/mounted:onpsaid/innershaft; . 3 because as first stator mounted (on) and boutside deaid direct drive thereon, wherein said second shaft has a four; griavod of , Raib briaisécondestatoramounted ontand toutside said secondadrive and wherein said casing has a fifth disk of magnet; prizuodial & bissenoquettades para prince prince de la contra del la contra del la contra del la contra de la contra de la contra del la contra de la contra de la contra del la disk, said first coil being adapted tibnge; thank rennield Maib Addimeans aform causing heach of isaid istators to simpress a bissuitable selectromagnetic field suponsits brespective rotor so 10 floas (to simpart rotary imotion theretogs bisa first shaft, and adapted to generate a mounted outside said casing gaissang4:02 Apparatusafor simparting arotary amotion to Jamdevice paiwithinca vacuum chamber comprising ain combination 13 biss a vacuum-tightatubularicasing of non-magnetic material, 15. said casing having a longitudinal axis, s mismera first shaft rotatably mounted inside said casing along Enssaid axis) isaid first shaft bhaving a first disk of magnetic wherein a disk is affixed to smoorthat barnom, land gaisass a second shaft rotatably mounted inside said casing about 20 said first shaft, said second shaft being tubular and having a second disk of magnetic material mounted thereon outside Apparatus in accordance with, findambrossibina a Disa mid first scoil mounted outside said casing and adapted to bacgenerate a magnetic field in said firstidisky bas , paisso 25 sisvilosacseconducoilomounted coutside said casing and adapted to generate a magnetic field in said secondidisk, brodes biss at least said first coil being adapted to generate a s first rotating field pattern for srotating said first shaft, bussaid ffirstudisk beingd magnetizedsin baltpattern mefortbeing within said birotated by said if irst rotating afield pattern. biss midia first shaft, said disk having a coded pattern of opaque ons shois en Apparatuse in faccordanced with claim 14; but erein caid second coil is adapted to generate a second rotating field pattern for rotating said second shaft, and wherein said 35 second disk is magnetized in a pattern for being rotated by said second rotating field pattern.

PCT/US94/04040 WO 94/23911 TOT

6. Apparatus min baccordance with claim 4 to wherein said evirfirst ishaft shas latthird disk tofumagnetic material mounted thereon, wherein said second shaft has a fourth disk of evimagnetic material mounted thereon adjacent to said third disk, and wherein said casing has a fifth disk of magnetic material a bismounted thereon inside asaid casing adjacent to ksaid second disk, said first coil being adapted toungemerate camfield s apattern of ora pressing isaid second disk and said sfifth disk oz together:for:braking:action:coupling said:second:shaft:to:said first shaft, said apparatus alsomincluding amthird acoil 00 10 mounted outside said casing and adapted to generate a enimagnetic field in said third disk and fourth disk for pressing said third disk and said fourth disk together for braking _fsaction_coupling-said1secondsshaftgto3said1casing. _

15 said casing having a longitudinal axis, pnois pn7330 Apparatus in accordance with claim a475 wherein a pigsensing mechanism is supported; on; and within said casing, and wherein a disk is affixed to said first shaft, Lisaid disk duchaving sa fcoded pattern madapted sto mactivate sessid sensing

said first shaft, said second shaft being tubul mainshaming 00 20 a second disk of magnetic material mounted thereon outside

Apparatus in accordance with claim 5770 wherein a of seconds sensing mechanism bish supported on cand within said casing, and wherein a second disk(is affixed #to said second

25 of shafthsaid diskshaving sa codedopattern adapted sto sactivate 38 generate a magnetic field is mainsanguerate a magnetic at least said first coil being adapted to generate a , Jane Junia Apparatustain raccordance swith iclaim J770 wherein a

puilight-emitting.cdiode land sagread heads are supported for and within said casing, and iwhereintar disk his raffixed to csaid 08 first shaft, said disk having a coded pattern of opaque preportions adapted to pass between said light emitting diode and second coil is adapted to generate a secorbseth bseth bisaeld pattern for rotating said second shaft, and wherein said second disk is magnetized in a pattern for being rotated by 28 35

said second rotating field pattern.

30

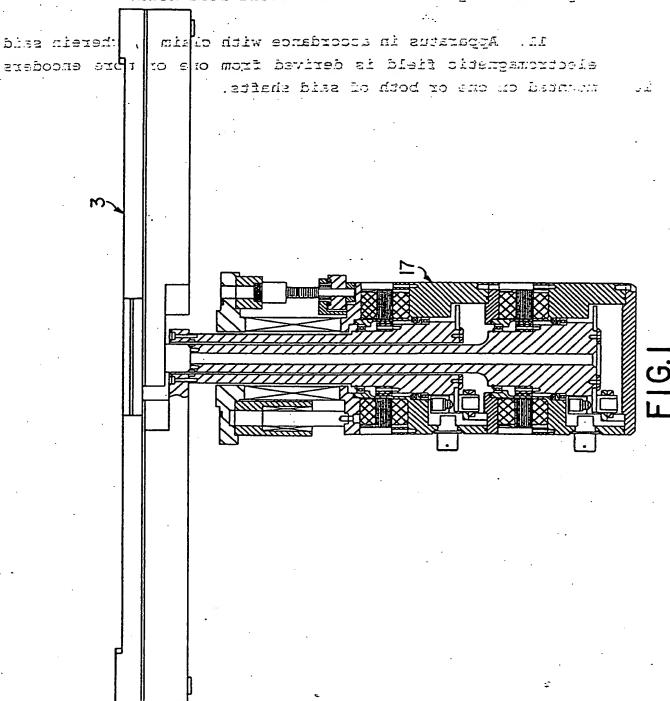
WO 94/23911 9 PCT/US94/04040

10. Apparatus in accordance with claim 8, wherein a second light-emitting diode and a second read head are supported on and within said casing, and wherein a second disk is affixed to said second shaft, said disk having a coded pattern of opaque portions adapted to pass between said second light-emitting diode and said second read head.

Apparatus in accordance with claim 1, wherein said electromagnetic field is derived from one or more encoders mounted on one or both of said shafts. 10

WO 94/23911 > PCT/US94/04040

10. Apparatus in accordance with claim 8, wherein a second light-emitting diode and a second read head are supported on and within said casing, and wherein a second disk is affixed to said second shaft, said disk having a coded pattern of opeque portions adapted to pass between said second light-emitting diode and said second read head.



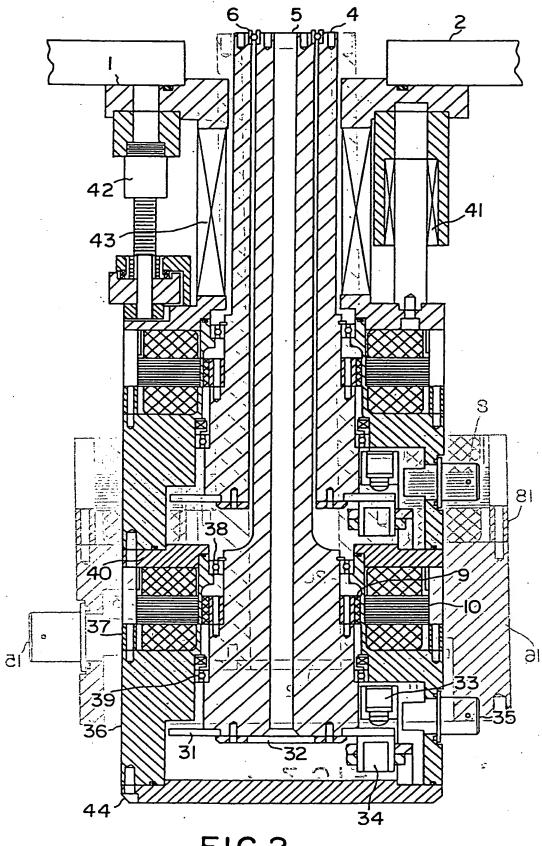


FIG. 2

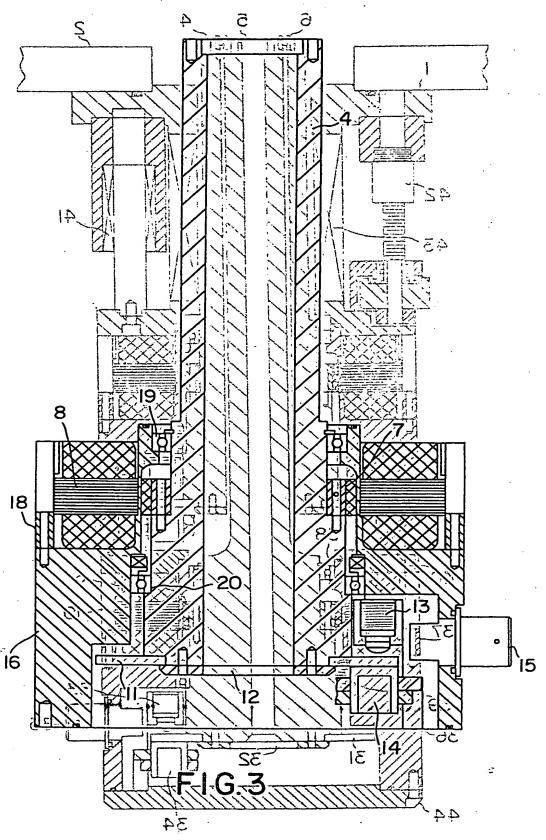
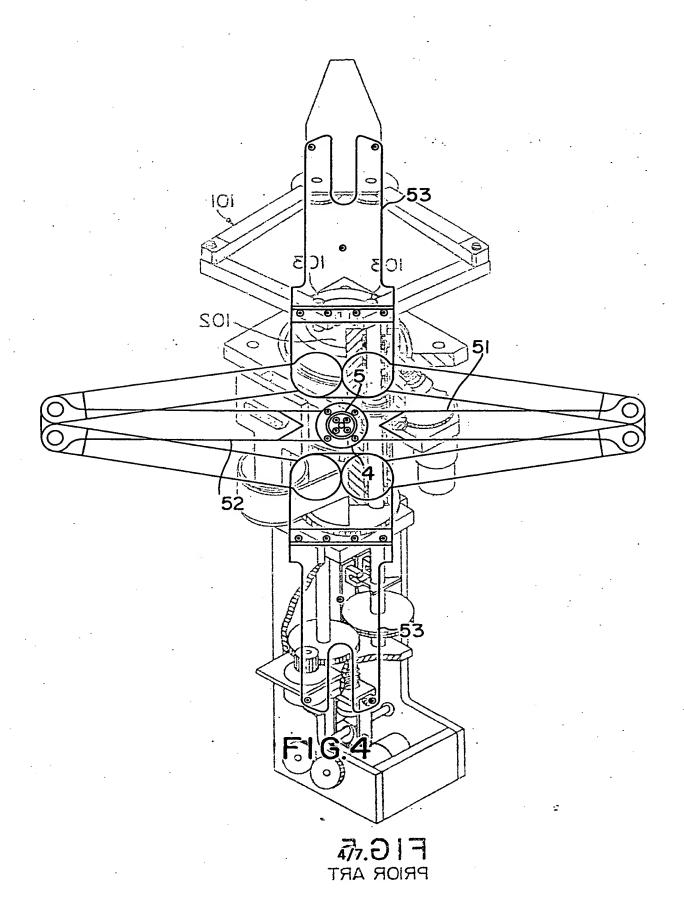


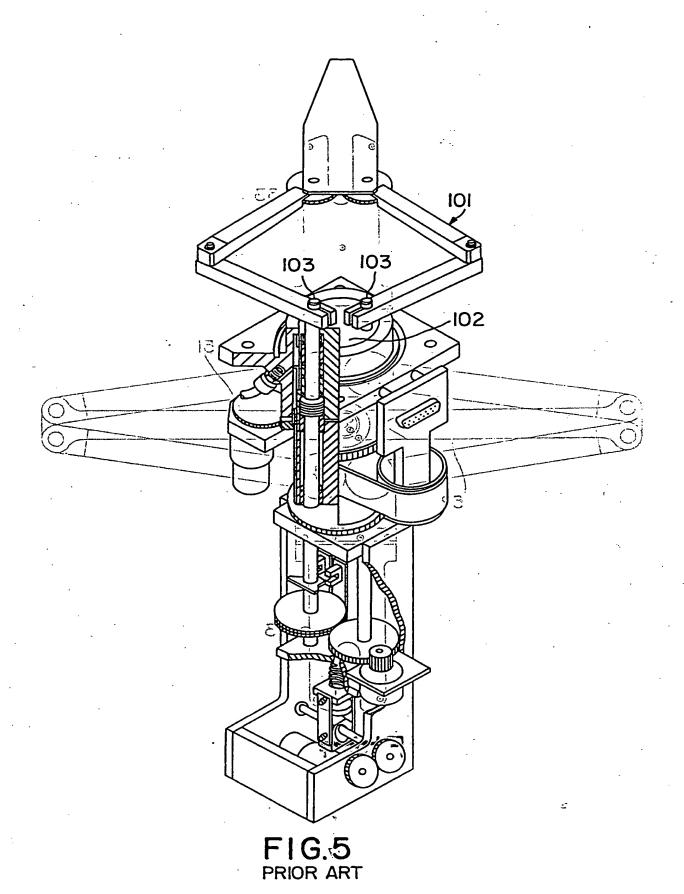
FIG7,2

WO_94/23911_0q PCT/US94/04040

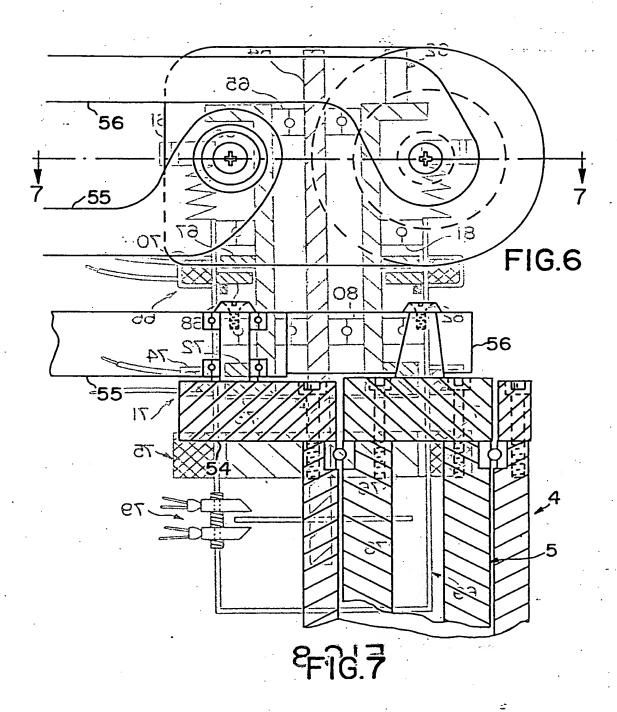


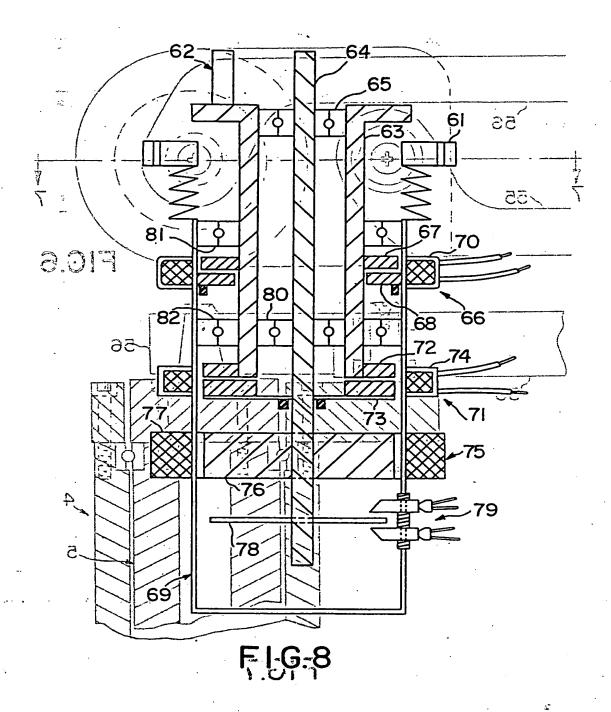
5/7

₩O 94/23911 PCT/US94/04040



5/7





INTERNATIONAL SEARCH REPORT EDEAS CA International application No. PCT/USTAICKLET

PCT/US94/04040

		Congression of the state of the	<u> </u>				
	(5)	SSIFICATION OF SUBJECT MATTER DESCRIPTION DELICATION OF SUBJECT MATTER DESCRIPTION DELICATION DELIC					
i	:US CL :: According t	:414/744.5; 901/23; 310/114; 192/18Biris mixture to secret international Patent Classification (IPC) or to both national	een ni bedeildasse need ton and troops i ional classification and IPC	क्तरीयत्थलं शंहरि			
		DS SEARCHED	1.80b1 as				
	Minimum d	ocumentation scarched (classification system followed by	Classification symbols) Men Yell en	Lacad			
	U.S.: 414/744.5, 744.2; 901/15,23,24; 310/67R, 75D, 88, 101, 103, 112, 114; 192/18B, 12D; 74/479 BP						
	Documental	ion searched other than minimum documentation to the ext	tent that such documents are included	in the fields searched			
	None			2. Ciri			
ห้อยะ	Electronic d	ata base consulted during the international search (name	of data base and, where practicable, innouncement is granted on that temp	search terms used)			
			e Erra Cheel.	रहे इन्डां प			
	C. DOC	UMENTS CONSIDERED TO BE RELEVANT		1			
٠).	Category*	Citation of document, with indication, where appropriate the company of the compa	priste, of the relevant passages	Relevant to claim No.			
	X	US,A, 5,270,600 (Hashimoto),14 De	ecember 1993,	1,4,5,11,			
	Y	c inventions in this bramational application, a fallows.	Scarciling Authority found multiple	2,3,7-10			
	Υ	US,A, 5,180,276 (Hendrickson) 19 . Figure 1B	January 1993;	2,3			
	Υ.	US,A, 4,712,971 (Fyler) 15 Decemb	er 1987	2,3			
	Y	JP,A, 2-292153 (Fuji Electric Co. Ltd Figures 12b (claim 2) and 9 (claim 3)		2,3			
archable	Y Lida etavoo	US,A, 3,768,714 (Applequist) 30 October 156,160,166.		7-10i			
ɔaymɛn:	id not invite	without effort justifying an additional fee, this Authority	carchable claims could be searched a additional fee.	£}			
ז כסעכוז		nch foce were timely naid by the applicant, this internation					
. [Furth	er documents are listed in the continuation of Box C.	See patent family annex.	enly ti			
	A dos	cial categories of cited documents: "T" unsent defining the general state of the art which is not considered to of particular relevance	later document published after the inte- date and not in conflict with the applica principle or theory underlying the inve	tion but cited to understand the			
	•	ier document published on or after the international filing date					
	°L° doc	umont which may throw doubts on priority claim(s) or which is d to establish the publication date of another citation or other	considered novel or cannot be consider when the document is taken alone document of particular relevance; the				
героп із	O cos insign	mely redo to content of the content of the call of the	considered to envolve an inventive	step when the document is			
		emont published prior to the international filing date but later than *&* priority date claimed	document member of the same patent	family			
	Date of the	actual completion of the international search Date	te of mailing of the international sea				
	21 JUNE	ices were accompanied by the applicants in peed in 1994.	199 JUL 70 O The additional acc	Maria insuma E			
	Name and n	address of the ISA/US and of add of the payment of add SU\ASI	thorized officer Aleone	new			
	Box PCT	***************************************	Underwood Underwood Underwood Unique (1) Unique (NAZETES			
	Facsimile N	· - '-	lephone No. (703) 308-1112				

PCT/US94/3/040

.091 go the INTERNATIONAL SEARCH REPORT ITHATE IN International application No. PCT/US94/04040

	Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)	A
	This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons: Out on a control of certain claims under Article 17(2)(a) for the following reasons: Out of the control of certain claims under Article 17(2)(a) for the following reasons:	A
	1. Claims Nos.: GEMOSAME EQUIPM .	8
	because they relate to subject matter not required to be searched by this Authority, namely:	
	U.S. : 414.744.5, 744.2; 901/15,23,24; 310/67R, 75D, C8, 101, 103, 112, 114; 192/182, 12D; 74/479 BP	
hed	ocumentation ocurvited other than minimum decommentation to the extent that ruch documents are included in the fields cent.	į
	2. Claims Nos.: 6	
(£	because they relate to parts of the international application that do not comply with the prescribed requirements an extent that no meaningful international search can be carried out, specifically:	- 1
	Please See Extra Sheet.	· i
	DOCUMENTS CONSTUBED TO BE RULEVANY	. <u></u>
: ==i	3. Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule to	5.4(a).
	Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)	X
	This International Searching Authority found multiple inventions in this international application, as follows:	:
	US,A, 5,180,276 (Hendrickson) 15 January 1993; 2,3 Agure 19	
	US, A, 712,971 (Fyler) 15 December 1987 2,3	Y
	JP, A, 2-292153 (Fuji Electric Co. Ltd.) 03 December 1990 2,3 Figures 12b (claim 2) and 9 (claim 3).	Y
	1. As all required additional search fees were timely paid by the applicant, this international search report covers a claims.	ll searchable
	2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not into of any additional fee.	vite payment
	3. As only some of the required additional search fees were timely paid by the applicant, this international search reports only those claims for which fees were paid, specifically claims Nos.:	report covers
	Further documents are listed in the continuation of Box C. See pateril lamily function	<u> </u>
inoin il bas	Special congrounce of cited documents: The later document published after the interpolated filling date or conflict with the application but cited to under document defining the are which is not considered principle or theory underlying the avenues to be of perfectlying the invention.	·^
	m national to white ade community automorphism to tourness and a t	·3.
	cited to establish the publicating date of enother creation or other	.1.
d tone i inst nucun	No required additional search fees were timely paid by the applicant. Consequently, this international sea restricted to the invention first mentioned in the claims; it is covered by claims Nos.:	reh report is
	document betyinghed before to the executational tiles date page page than . The document another of the same broad family the better than the same broad family and the same better than the same broad family the best family and the same broad family the same broad	.4.
i i	is of the actival completion of the international search Date of mailing of the international search report	DE
	Remark on Protest The additional search fees were accompanied by the applicant's protest. I SNULL	2
	No protest accompanied the payment of additional search fees this gailiam has an	Na
1	Form PCT/ISA/210 (continuation of first shoct(1))(July 1992)*	4 1

INTERNATIONAL SEARCH REPORT

International application No. PCT/US94/04040

BOX I. OBSERVATIONS WHERE CLAIMS WERE FOUND UNSEARCHABLE

2. Where no meaningful search could be carried out, specifically:

Claim 6 appears to be directed to the structure in figure 8 but depends from claim 4 which is directed to the structure in figure 1. Since the two figures are directed to different drive structures it is unclear what structure is being claimed. It appear maybe first coil in line 7 of claim 6 should be second coil.

This Page is inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

	BLACK BORDERS
	IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
0	FADED TEXT OR DRAWING
	BLURED OR ILLEGIBLE TEXT OR DRAWING
	SKEWED/SLANTED IMAGES
	COLORED OR BLACK AND WHITE PHOTOGRAPHS
	GRAY SCALE DOCUMENTS
	LINES OR MARKS ON ORIGINAL DOCUMENT
	REPERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
	OTHER:

IMAGES ARE BEST AVAILABLE COPY.
As rescanning documents will not correct images problems checked, please do not report the problems to the IFW Image Problem Mailbox